

CLAIMS

1. An eye-characteristics measurement apparatus comprising:

5 a first light-source section for emitting a light beam having a first wavelength;

a first illumination optical system for illuminating a minute area on the retina of an eye under measurement, with a light beam emitted from the first light-source section;

10 a compensation optical section for compensating for aberration of a light beam transmitted or reflected, according to the amount of compensation given based on an optical characteristic of a reflected light beam which is reflected and returned from the retina of the eye under measurement;

15 a first light-receiving optical system for receiving a part of the reflected light beam which is reflected and returned from the retina of the eye under measurement, through the compensation optical section and a first conversion member having a long focal length or a high sensitivity for converting to at least substantially 17 beams;

20 a first light-receiving section for receiving a light beam received by the first light-receiving optical system;

a third light-source section for illuminating the compensation optical section with a light beam having a third wavelength;

25 a third light-receiving optical system for receiving a light beam emitted from the third light-source section, through the compensation optical section and a third conversion member for converting to at least substantially 17 beams;

30 a third light-receiving section for receiving a light

beam received by the third light-receiving optical system;

5 a second light-receiving optical system for receiving a part of the reflected light beam which is reflected and returned from the retina of the eye under measurement, through the compensation optical section and a second conversion member having a short focal length, a low sensitivity, or a high density for converting to at least substantially 17 beams;

10 a second light-receiving section for receiving a light beam received by the second light-receiving optical system;

a compensation-amount calculation section for obtaining an optical characteristic of the eye under measurement based on the output of the second light-receiving section, for obtaining the amount of compensation based on the optical characteristic, and for outputting the amount of compensation to the compensation optical section; and

20 a measurement calculation section for measuring an optical characteristic compensated by the compensation optical section based on the output of the third light-receiving section and an optical characteristic based on the output of the first light-receiving section, obtained after the compensation of the compensation optical section, and for obtaining an optical characteristic of the eye under measurement according to the measured optical characteristics.

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2. An eye-characteristics measurement apparatus comprising:

a first light-source section for emitting a light beam having a first wavelength;

30 a first illumination optical system for illuminating a minute area on the retina of an eye under measurement, with a

light beam emitted from the first light-source section;

a compensation optical section for compensating for aberration of a light beam transmitted or reflected, according to the amount of compensation given based on an optical
5 characteristic of a reflected light beam which is reflected and returned from the retina of the eye under measurement;

a third light-source section for illuminating the compensation optical section with a light beam having a third wavelength;

10 a first light-receiving optical system for receiving a part of the reflected light beam which is reflected and returned from the retina of the eye under measurement and the light beam emitted from the third light-source section, through the compensation optical section and a first
15 conversion member having a long focal length or a high sensitivity for converting to at least substantially 17 beams;

a first light-receiving section for receiving a light beam received by the first light-receiving optical system;

a second light-receiving optical system for receiving a
20 part of the reflected light beam which is reflected and returned from the retina of the eye under measurement, through the compensation optical section and a second conversion member having a short focal length, a low sensitivity, or a high density for converting to at least substantially 17
25 beams;

a second light-receiving section for receiving a light beam received by the second light-receiving optical system;

a compensation-amount calculation section for obtaining an optical characteristic of the eye under measurement based
30 on the output of the second light-receiving section, for

obtaining the amount of compensation based on the optical characteristic, and for outputting the amount of compensation to the compensation optical section; and

5 a measurement calculation section for measuring an optical characteristic compensated by the compensation optical section based on the output of the first light-receiving section caused by the light beam emitted from the third light-source section, for measuring an optical characteristic obtained after the compensation of the compensation optical
10 section based on the output of the first light-receiving section caused by the light beam emitted from the first light-source section, and for obtaining an optical characteristic of the eye under measurement according to the measured optical characteristics.

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3. An eye-characteristics measurement apparatus comprising:

a first light-source section for emitting a light beam having a first wavelength;

20 a first illumination optical system for illuminating a minute area on the retina of an eye under measurement, with a light beam emitted from the first light-source section;

a first light-receiving optical system for receiving a part of a reflected light beam which is reflected and returned from the retina of the eye under measurement, through a first
25 conversion member having a long focal length or a high sensitivity for converting to at least substantially 17 beams;

a second light-receiving optical system for receiving a part of the reflected light beam which is reflected and returned from the retina of the eye under measurement, through
30 a second conversion member having a short focal length, a low

sensitivity, or a high density for converting to at least substantially 17 beams;

a first light-receiving section for receiving a light beam received by the first light-receiving optical system;

5 a second light-receiving section for receiving a light beam received by the second light-receiving optical system;

a compensation-amount calculation section for obtaining an optical characteristic of the eye under measurement based on the output of the first light-receiving section and/or the
10 second light-receiving section, and for obtaining and outputting the amount of compensation required to cancel aberration based on the optical characteristic;

a compensation optical section for applying aberration compensation based on the amount of compensation output from
15 the compensation-amount calculation section to the reflected light beam from the retina of the eye under measurement, or to both an illumination light beam coming from the first illumination optical system and the reflected light beam from the retina of the eye under measurement; and

20 a measurement calculation section for obtaining an optical characteristic of the eye under measurement according to an optical characteristic based on the output of the first light-receiving section and/or the second light-receiving section, obtained after the compensation of the compensation
25 optical section, and an optical characteristic compensated by the compensation optical section.

4. An eye-characteristics measurement apparatus according to one of Claims 1 to 3, wherein the second light-receiving
30 optical system is configured so as to be able to perform

signal processing more easily and quickly due to a setting in which the change of a beam converted by the second conversion member over a measurement possible area is set smaller than the conversion pitch of the second conversion member.

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5. An eye-characteristics measurement apparatus according to Claim 3 or 4, wherein

the compensation-amount calculation section obtains the optical characteristic of the eye under measurement based on the output of the second light-receiving section, and obtains
10 and outputs the amount of compensation required to cancel aberration based on the optical characteristic, and

the measurement calculation section is configured so as to obtain the optical characteristic of the eye under
15 measurement at a high sensitivity based on the optical characteristic based on the output of the first light-receiving section and the optical characteristic compensated by the compensation optical section.

20 6. An eye-characteristics measurement apparatus according to one of Claims 3 to 5, further comprising:

a third light-source section for emitting a light beam to illuminate the compensation optical section;

a third light-receiving optical system for receiving a
25 light beam emitted from the third light-source section, through the compensation optical section and a third conversion member for converting to at least substantially 17 beams;

a third light-receiving section for receiving a light
30 beam received by the third light-receiving optical system,

wherein the measurement calculation section is configured so as to measure the optical characteristic compensated by the compensation optical section, based on the output of the third light-receiving section and to obtain the optical characteristic of the eye under measurement by using the measured optical characteristic.

7. An eye-characteristics measurement apparatus according to Claim 1 or 6, wherein

10 the wavelength of a light beam emitted from the third light-source section is different from the first wavelength of the first light-source section, and

the measurement calculation section is configured so as to measure in parallel the optical characteristic based on the output of the first light-receiving section, obtained after the compensation of the compensation optical section and the optical characteristic compensated by the compensation optical section based on the output of the third light-receiving section.

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8. An eye-characteristics measurement apparatus according to one of Claims 3 to 5, further comprising a third light-source section for emitting a light beam to illuminate the compensation optical section,

25 wherein the first light-receiving section further receives a light beam emitted from the third light-source section, through the compensation optical section and the first conversion member, and

the measurement calculation section is configured so as to measure the optical characteristic compensated by the

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compensation optical section, based on the output of the first light-receiving section caused by a light beam emitted from the third light-source section, and to use the measured optical characteristic to obtain the optical characteristic of the eye under measurement.

9. An eye-characteristics measurement apparatus according to Claim 2 or 8, wherein the measurement calculation section turns on and off the first and third light-source sections or inserts light-beam blocking means in an optical path coming from the first and third light-source section to switch or select the light beam to be received by the first light-receiving section.

10. An eye-characteristics measurement apparatus according to Claim 6 or 8, wherein

the third light-source section is formed of a light source common with the first light-source section, and

a part of a light beam emitted from the first light-source section is used as a light beam emitted from the third light-source section.

11. An eye-characteristics measurement apparatus comprising:

a first light-source section for emitting a light beam having a first wavelength;

a first illumination optical system for illuminating a minute area on the retina of an eye under measurement, with a light beam emitted from the first light-source section;

a first light-receiving optical system for receiving a part of a reflected light beam which is reflected and returned

from the retina of the eye under measurement, through a first conversion member for converting to at least substantially 17 beams;

5 a first light-receiving section for receiving a light beam received by the first light-receiving optical system;

a second light-source section for emitting a light beam having a second wavelength;

10 an eye-front-part illumination section for illuminating a portion close to the retina of the eye under measurement at a predetermined pattern with a light beam emitted from the second light-source section;

an eye-front-part observation section for receiving a reflected light beam which is reflected and returned from the portion close to the retina of the eye under measurement;

15 an eye-front-part-image light-receiving section for receiving a light beam received by the eye-front-part observation section;

20 a compensation-amount calculation section for obtaining an optical characteristic of the eye under measurement based on the output of the eye-front-part-image light-receiving section, and for obtaining and outputting the amount of compensation required to cancel aberration based on the optical characteristic;

25 a compensation optical section for applying aberration compensation based on the amount of compensation output from the compensation-amount calculation section to the reflected light beam from the retina of the eye under measurement, or to both an illumination light beam coming from the first illumination optical system and the reflected light beam from
30 the retina of the eye under measurement; and

a measurement calculation section for obtaining an optical characteristic of the eye under measurement according to an optical characteristic based on the output of the first light-receiving section, obtained after the compensation of the compensation optical section, and an optical characteristic compensated by the compensation optical section.

12. An eye-characteristics measurement apparatus according to Claim 11, wherein the measurement calculation section is configured so as to further obtain the shape of the cornea of the eye under measurement based on the output of the eye-front-part-image light receiving section.

13. An eye-characteristics measurement apparatus according to Claim 11 or 12, further comprising:

a third light-source section for emitting a light beam to illuminate the compensation optical section;

a third light-receiving optical system for receiving a light beam emitted from the third light-source section, through the compensation optical section and a third conversion member for converting to at least substantially 17 beams; and

a third light-receiving section for receiving a light beam received by the third light-receiving optical system,

wherein the measurement calculation section is configured so as to measure the optical characteristic compensated by the compensation optical section, based on the output of the third light-receiving section and to obtain the optical characteristic of the eye under measurement by using the measured optical characteristic.

14. An eye-characteristics measurement apparatus according to Claim 13, wherein

the wavelength of a light beam emitted from the third
5 light-source section is different from the first wavelength of the first light-source section, and

the measurement calculation section is configured so as to measure in parallel the optical characteristic based on the output of the first light-receiving section, obtained after
10 the compensation of the compensation optical section and the optical characteristic compensated by the compensation optical section based on the output of the third light-receiving section.

15 15. An eye-characteristics measurement apparatus according to Claim 11 or 12, further comprising a third light-source section for emitting a light beam to illuminate the compensation optical section,

wherein the first light-receiving section further
20 receives a light beam emitted from the third light-source section, through the compensation optical section and the first conversion member, and

the measurement calculation section is configured so as to measure the optical characteristic compensated by the
25 compensation optical section, based on the output of the first light-receiving section caused by a light beam emitted from the third light-source section, and to use the measured optical characteristic to obtain the optical characteristic of the eye under measurement.

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16. An eye-characteristics measurement apparatus according to Claim 15, wherein the measurement calculation section turns on and off the first and third light-source sections or inserts light-beam blocking means in an optical path coming from the first and third light-source sections to switch the light beam to be received by the first light-receiving section.

17. An eye-characteristics measurement apparatus according to one of Claims 13 to 15, wherein
the third light-source section is formed of a light source common with the first light-source section, and
a part of a light beam emitted from the first light-source section is used as a light beam emitted from the third light-source section.

18. An eye-characteristics measurement apparatus comprising:
a first light-source section for emitting a light beam having a first wavelength;

a first illumination optical system for illuminating a minute area on the retina of an eye under measurement, with a light beam emitted from the first light-source section;

a first light-receiving optical system for receiving a part of a reflected light beam which is reflected and returned from the retina of the eye under measurement, through a first conversion member for converting to at least substantially 17 beams;

a first light-receiving section for receiving a light beam received by the first light-receiving optical system;

a compensation-amount calculation section for obtaining an optical characteristic of the eye under measurement based

on the output of the first light-receiving section, and for obtaining and outputting the amount of compensation required to cancel aberration based on the optical characteristic;

5 a compensation optical section for applying aberration compensation based on the amount of compensation output from the compensation-amount calculation section to the reflected light beam from the retina of the eye under measurement, or to both an illumination light beam coming from the first illumination optical system and the reflected light beam from
10 the retina of the eye under measurement;

a third light-source section for emitting a light beam to illuminate the compensation optical section;

a third light-receiving optical system for receiving a light beam emitted from the third light-source section,
15 through the compensation optical section and a third conversion member for converting to at least substantially 17 beams;

a third light-receiving section for receiving a light beam received by the third light-receiving optical system; and

20 a measurement calculation section for measuring an optical characteristic based on the output of the first light-receiving section, obtained after the compensation of the compensation optical section, and an optical characteristic compensated by the compensation optical section based on the
25 output of the third light-receiving section, and for obtaining an optical characteristic of the eye under measurement according to the measured optical characteristics.

19. An eye-characteristics measurement apparatus according to
30 Claim 18, wherein

the wavelength of a light beam emitted from the third light-source section is different from the first wavelength of the first light-source section, and

the measurement calculation section is configured so as
5 to measure in parallel the optical characteristic based on the output of the first light-receiving section, obtained after the compensation of the compensation optical section and the optical characteristic compensated by the compensation optical section based on the output of the third light-receiving
10 section.

20. An eye-characteristics measurement apparatus according to Claim 18 or 19, wherein

the third light-source section is formed of a light
15 source common with the first light-source section, and

a part of a light beam emitted from the first light-source section is used as a light beam emitted from the third light-source section.

20 21. An eye-characteristics measurement apparatus comprising:

a first light-source section for emitting a light beam having a first wavelength;

a first illumination optical system for illuminating a minute area on the retina of an eye under measurement, with a
25 light beam emitted from the first light-source section;

a third light-source section for emitting a light beam used for measuring aberration compensated for;

a first light-receiving optical system for receiving a part of a reflected light beam which is reflected and returned
30 from the retina of the eye under measurement and a light beam

emitted from the third light-receiving section, through a first conversion member for converting to at least substantially 17 beams;

5 a first light-receiving section for receiving a light beam received by the first light-receiving optical system;

a compensation-amount calculation section for obtaining an optical characteristic of the eye under measurement based on the output of the first light-receiving section, and for obtaining and outputting the amount of compensation required
10 to cancel aberration based on the optical characteristic;

a compensation optical section for applying aberration compensation based on the amount of compensation output from the compensation-amount calculation section to the reflected light beam from the retina of the eye under measurement and a
15 light beam coming from the third light-source section, or to an illumination light beam coming from the first illumination optical system, the reflected light beam from the retina of the eye under measurement, and the light beam coming from the third light-source section; and

20 a measurement calculation section for measuring an optical characteristic compensated by the compensation optical section based on the output of the first light-receiving section caused by the light beam emitted from the third light-source section, for measuring an optical characteristic
25 obtained after the compensation of the compensation optical section based on the output of the first light-receiving section caused by the light beam emitted from the first light-source section, and for obtaining an optical characteristic of the eye under measurement according to the measured optical
30 characteristics.

22. An eye-characteristics measurement apparatus according to Claim 21, wherein the measurement calculation section turns on and off the first and third light-source sections or inserts
5 light-beam blocking means in an optical path coming from the first and third light-source sections to switch or select the light beam to be received by the first light-receiving section.

23. An eye-characteristics measurement apparatus according to
10 Claim 21, wherein
the third light-source section is formed of a light source common with the first light-source section, and
a part of a light beam emitted from the first light-source section is used as a light beam emitted from the third
15 light-source section.

24. An eye-characteristics measurement apparatus according to one of Claims 1 to 23, wherein the compensation optical section comprises
20 a first compensation optical section for applying aberration compensation to an illumination light beam coming from the first illumination optical system, and
a second compensation optical section for applying aberration compensation to the reflection light beam from the
25 retina of the eye under measurement.

25. An eye-characteristics measurement apparatus according to Claim 24, further comprising:
a fourth light-receiving optical system for receiving a
30 part of a light beam emitted from the first light-source

section, through the first compensation optical section and a fourth conversion member for converting to at least substantially 17 beams; and

5 a fourth light-receiving section for receiving a light beam received by the fourth light-receiving optical system,

wherein the third light-source section illuminates the second compensation optical section;

10 the third light-receiving section receives a light beam emitted from the third light-source section, through the second compensation optical section and the third conversion member; and

the measurement calculation section is configured so as to further measure the optical characteristic compensated by the second compensation optical section based on the output of
15 the third light-receiving section and to use the measured optical characteristic to obtain the optical characteristic of the eye under measurement.

26. An eye-characteristics measurement apparatus according to
20 one of Claims 1 to 25, wherein the compensation-amount calculation section is configured so as to be able to compensate for a spherical-power component, which is a lower-order aberration, based on the optical characteristic of the eye under measurement by moving the first illumination optical
25 system and/or the first light-receiving optical system.

27. An eye-characteristics measurement apparatus according to one of Claims 1 to 25, wherein the compensation-amount calculation section is configured such that a spherical-power
30 component and/or an astigmatic component, which are lower-

order aberrations, is compensated for by moving the first light-receiving optical system and/or changing the state of a part of the elements of the first light-receiving optical system, and the compensation optical section performs
5 compensation including at least a higher-order component of the other optical characteristics.

28. An eye-characteristics measurement apparatus according to one of Claims 1 to 27, wherein the compensation optical
10 section is configured so as to perform compensation including at least a higher-order component of the optical characteristic of the eye under measurement.

29. An eye-characteristics measurement apparatus according to
15 one of Claims 1 to 28, wherein the compensation optical section is formed of at least either a liquid-crystal spatial optical modulator or a deformable mirror.

30. An eye-characteristics measurement apparatus according to
20 one of Claims 1 to 29, wherein the optical characteristic of the eye under measurement is displayed after the compensation of the compensation optical section, and aberration is further compensated for by the compensation-amount calculation section and the compensation optical section according to an
25 instruction from an input section.

31. An eye-characteristics measurement apparatus according to one of Claims 1 to 30, wherein the compensation-amount calculation section is configured so as to obtain the amount
30 of compensation such that the obtained optical characteristic

of the eye under measurement is not completely canceled.

32. An eye-characteristics measurement apparatus according to one of Claims 1 to 31, wherein the first illumination optical system is configured so as to illuminate the minute area on the retina of the eye under measurement with a wide beam when passing through the cornea of the eye under measurement by a light beam emitted from the first light-source section.

33. An eye-characteristics measurement apparatus according to one of Claims 1 to 31, wherein the first illumination optical system is configured so as to illuminate the minute area on the retina of the eye under measurement with a narrow beam by a light beam emitted from the first light-source section.

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34. An eye-characteristics measurement apparatus according to Claim 33, wherein the first illumination optical system comprises a light-beam incident-position change section capable of changing the position where the narrow beam for illumination is incident on an eye-front-part of the eye under measurement, in a direction perpendicular to the optical axis.